"A Research into the Heat Regulation of the Body by an Investigation of Death Temperatures." By EDRED M. CORNER, M.A., M.B., B.C. (Cantab.), F.R.C.S., B.Sc. (Lond.), Surgeon to Out-patients, St. Thomas's Hospital, and Assistant-Surgeon to the Hospital for Sick Children, Great Ormond Street, Erasmus Wilson Lecturer, Royal College of Surgeons, and JAMES E. H. SAWYER, M.A., M.D. (Oxon.), M.R.C.P., Honorary Anæsthetist to the Ear and Throat Hospital, Birmingham, lately House Physician to St. Thomas's Hospital. Communicated by Professor J. N. LANGLEY, F.R.S. Received April 4, —Read May 5, 1904.

The fact has long been known that, in many forms of disease, variations of the bodily temperature occur as death approaches. Our knowledge of such variations is limited to certain apparently sporadic cases. Hitherto, no attempt has been made to ascertain the special class of disease in which such deviations occur most frequently, nor has the subject been examined in a scientific light, so as to bring these death temperatures in line with the present knowledge of the mode of production of pyrexia. It is towards this latter object that this inquiry has been directed. Further encouragement to bring forward this new source of knowledge is given by Sir John Burdon Sanderson, who says "the subject (of pyrexia) is one in respect of which results as valuable can be obtained by clinical investigation as by experiments on animals."*

This communication has been divided into two parts. In the first part, a general account is given of the bodily temperature immediately preceding death, and of the variations which are seen in these thermometric records. A series of problems are shown, in order to ascertain, where possible, the different factors which may influence the variations in the death temperatures. The figures quoted are, in all cases, the absolute minimum, as numbers of these cases have to be rejected for many reasons; for example, those in which tepid sponging has been employed, and others where the records are incomplete. In the second part, an attempt is made to ascertain the possible influences which may cause such variations in the bodily temperature, and to explain, from a study of these changes, the mechanism by which the temperature of the body is regulated in health, and the reasons for which deviations from the normal occur in disease.

PART I.

As the fatal result approaches, the curve on the temperature chart may exhibit several changes. In 49 per cent. of surgical, and in

* Clifford Allbutt, 'System of Medicine,' vol. 1, p. 152.

19 per cent. of medical cases, a definite change of over 1°·5 F. occurs during the 12 hours immediately preceding death. These figures are the absolute minimum for about 2500 consecutive cases which have been collected from the records of St. Thomas's Hospital. In instances where no such sudden change occurs, the temperature may remain about the same level, but the more usual procedure is for it to slowly and steadily fall. On the other hand, it is not common for the bodily temperature to rise slowly, for, when an elevation occurs at all, the change is generally a sudden one. The character of the temperature charts as death approaches is naturally affected by the types of fever from which the patients may be suffering, such as remittent, intermittent, etc. The influence of these fevers cannot be eliminated, and it is an interesting point that such cases frequently show a very decided variation in the character of the temperature near the fatal termination. The performance of tepid sponging, or the exhibition of antipyretic drugs, just before the death of the patient, renders the chart valueless for this research. For these, and similar reasons, many variations of temperature have been necessarily neglected.

There are other changes in the temperature charts which have to be considered in these investigations. Sometimes, about 24 hours before death, the temperature falls suddenly, anything from 1—5° F., and then rises rapidly, and at this point death may occur. On the other hand, the fatal result may be postponed, and, after the temperature has reached its maximum, defervescence may begin again. Such fluctuations as these are more commonly found among surgical than among medical cases. The following is a good example of these changes:—a baby girl, aged 7 weeks, was severely burnt, and died on the fifth day; the temperature during the last 36 hours of life represented these variations; it fell 4°·3, rose 6°·4, falling again 4°·2. Again, in a woman, aged 28 years, who suffered from general peritonitis and appendicitis, there was a fall of 4° in the temperature, followed by a rise of 8°, when death occurred. These early deviations of the temperature begin about 24 hours before the death of the patient, and may exaggerate either the death rise or the death fall, or may mask them altogether.

Of the 2500 cases which were examined, 1305 were medical cases, the remainder, 1195, being surgical. Changes in the bodily temperature of over 1°·5, occurring during the last 12 hours of life, were found in 34 per cent. of all the records examined; in 49 per cent. of surgical, and in only 19 per cent. of medical cases. On account of this great difference of 30 per cent., the two lists of cases have been kept separate, although in many instances they overlap. The explanation of the difference which is found between the medical and surgical cases has to be sought for in the other particulars.

Of the variations found among the fatal medical cases, 75 per cent. were rises of temperature and 25 per cent. falls. For the surgical cases, the corresponding percentages were 73 and 27; the two classes agreeing very closely. Elevations of temperature occurred in 26 per cent., and falls in 8 per cent., of all the cases examined.

The relative proportions of male to female deaths were also investigated, and the following figures were obtained:—

Medical Cases.

Proportion of male to female deaths during the same period	1·75	male to	1	female.
Ditto, showing death rise of temperature	1·57	,,	1	,,
Ditto, showing death fall of temperature	1·45	,,	1	,,

Surgical Cases.

Proportion of male to female deaths during the same period	1·63	male to	1	female.
Ditto, showing death rise of temperature	1·75	,,	1	,,
Ditto, showing death fall of temperature	1·39	,,	1	,,

The following deductions may be made from these figures, indicating lines along which an explanation of the phenomenon may be sought. In surgical cases males are more apt to show a death rise; females, on the other hand, show a marked tendency to death falls. In medical cases the difference is not so marked, but female patients are relatively more liable to death variations of temperature than are male. A fall of temperature in both medical and surgical cases is more common in females than in males.

There is one point on which medical and surgical cases differ from each other, and that is, that in the latter deaths due to injury are included. As to the actual cause of death in disease and in injury the difference is not so great, but, as will be seen in the following table, the death temperatures vary considerably in one important point in the two classes. Only the surgical cases are here considered:—

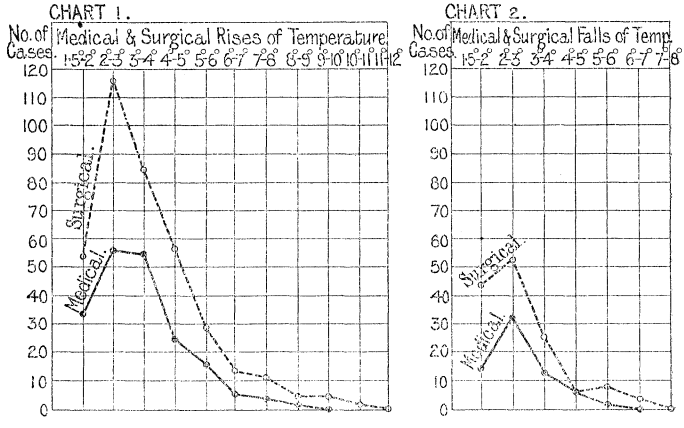
Proportion of deaths due to disease and injury	1·88	disease to	1	injury.
Ditto, showing death rise	1·84	,,	1	,,
Ditto, showing death fall	3·29	,,	1	,,

These figures show that rises in the bodily temperature, just before death occurs, are found to be present in fairly equal proportion in patients dying from disease and from injury. Falls of temperature, however, are very much more common in patients suffering from disease. The following table shows the same proportions in percentages:—

	Disease.	Injury.
Proportion of death changes to total ...	51·7 per cent.	46·0 per cent.
„ „ rises „ ...	30·5 „	37·3 „
„ „ falls „ ...	15·2 „	8·7 „

From this table it would appear that changes of temperature, as death approaches, occur less frequently in injuries than in disease, and that this difference is due to the comparative rarity of death falls in the former. The rises of temperature are present in equal proportion in the two classes of cases.

In the following charts an attempt is made to show the amount and frequency of the various deviations of temperature :—



The following conclusions may be drawn from Charts 1 and 2 :—

1. That death rises of temperature are naturally larger than death falls.

2. That small variations of temperature are more common than large.

3. That death rises are comparatively rare over 5° ; more so over 6°.

4. That death falls are comparatively rare over 4° ; more so over 5°.

5. That the variations of temperature in the medical and surgical cases agree fairly well, although death rises in medical cases are relatively more common from 3—4°.

6. That death rises are more frequently of greater magnitude in surgical than in medical cases.

Charts 3 and 4 show the actual temperature at the time of death (or rather the last recorded while life was still present) in cases in which there had been a previous thermometric variation of over 1°·5.

CHART 3.

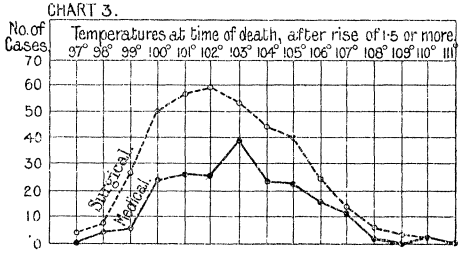
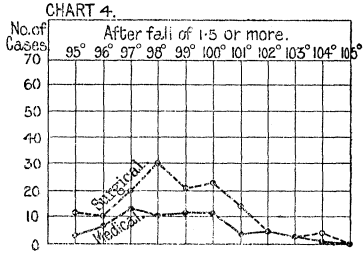


CHART 4.



From these charts the following deductions are made :—

1. That there is very little difference between medical and surgical cases as regards the final temperature, whether it be preceded by a rise or by a fall.

2. That, when death rises occur, the final temperature is most frequently between 101° and 103°, but quite commonly ranges from 100—106°.

3. That, after death falls, the most common final temperature is between 97° and 100°, but falls as low as 95° are fairly frequent. The high temperatures which are recorded under the death falls are due to the previous rises of temperature, just as the low temperatures under the death rises are due to previous falls.

The variations of the temperature of the preagonistic stage are considered in the following table with respect to the duration of the illness as estimated roughly by the length of the period between admission to the hospital and the death of the patient. This method by no means tells correctly the duration of the illness; but by no other way can it be estimated on account of the histories being so unreliable. It was decided in consequence to accept the above method only in surgical cases, as indicating fairly well in this class the state of affairs :—

Duration of stay in hospital.	Rises.		Falls.	
1 day	72	.....	21	
2 days.....	57	.....	12	
3 „	18	.....	8	
4 „	21	1st week,	6	1st week,
5 „	41	236	12	68
6 „	14	.....	7	
7 „	12	.....	2	
7 „ to 10 days	29	2nd week,	12	2nd week,
10 „ „ 14 „	34	63	10	22
14 „ „ 21 „	25	.....	18	
21 „ „ 28 „	19	.....	9	
1 „ „ 2 months ...	35	.....	16	
2 „ „ 3 „ ...	5	.....	0	
3 „ „ 4 „ ...	4	.....	4	
Over 4 „ ...	4	.....	2	

Owing to the obvious errors that enter into the composition of such a table, it was decided not to continue it into details. The nature of the disease would be expected to affect the death changes of temperature far more than the mere duration of the illness would. But one point stands out in the above table, namely, that the shorter the illness the greater the number of cases in which variations of temperature are found. How far this is relative or absolute has not been calculated, for the reasons which have just been given. The greatest number of rises are found in short illnesses; but the corresponding statement, as founded on the above table, which is composed only of surgical cases, does not hold good for the falls of temperature, but, as will be seen later, there is distinct evidence that sudden depressions of temperature as death approaches occur frequently in diseases of long duration.

The disease which brings about the fatal termination may be regarded as the most important factor in causing the changes of temperature which occur as death approaches. The influence of the disease upon the character of the pyrexia, when death is associated with a rise of the bodily temperature, has already been slightly indicated. The following diseases are those in which the greatest variations were found:—

Medical Cases.

Rise of 8°.—Acute yellow atrophy of the liver.

7°.—Septic meningitis, tubercular meningitis, typhoid fever (hæmorrhage, preceded by a fall of temperature).

6°.—General tuberculosis, cerebral hæmorrhage, septic meningitis, peritonitis, marasmus and diarrhœa.

5°.—Peritonitis; intussusception, preceded by a fall (two cases); general tuberculosis (three cases), pneumonia (two cases), diphtheria, chronic renal disease, carcinoma of the liver, intestinal obstruction, carcinoma of the small gut, hemiplegia, ulcerative endocarditis, acute yellow atrophy.

The list of diseases for the smaller elevations of temperature is too long for reproduction. Two points are clearly seen in this table—that in severe toxic diseases a large rise of temperature is common, and that in heart diseases it is a rare affection.

Surgical Cases.

Rise of 10°.—Fractured base of skull.

9°.—Fractured spine, fractured skull, burn.

8°.—Strangulated hernia and peritonitis, tetanus, pyæmia.

7°.—Septicæmia, intestinal obstruction and peritonitis, fractured vault of skull, fractured base, burn (two cases), pyæmia, suppurative nephritis, septic broncho-pneumonia.

Rise of 6°.—Peritonitis, various causes (five cases); meningitis (two cases), burn, scald, spina bifida, imperforate anus, gluteal abscess.

From this list the following conclusions may be drawn:—

1. That injuries to the head and spine generally give rise to high death changes of temperature. This may be emphasised by the low temperature which precede the final rise and which are the result of the shock caused by the injuries. Such a condition is frequently found in those patients who succumb within 24 hours after admission to the hospital.*

2. That the following diseases are the most frequent in taking the first places among the death rises of temperature:—

Head injuries: 10°, 1; 9°, 1; 8°, 1; 7°, 2; 6°, 1; 5°, 5—11 cases.
Spinal injuries: 9°, 1; 6°, 1; 5°, 1—3 cases.
Burns: 9°, 1; 7°, 2; 6°, 1; 5°, 6—10 cases.
Scalds: 6°, 1; 5°, 1—2 cases.
Meningitis: 6°, 2—2 cases.

3. Besides the above, death in those cases associated with a rise of temperatures is almost always due to some form of poisoning by septic organisms. Thus the remainder of the list of cases with a death rise of 5° or more, can be summed up as follows:—Peritonitis, septicæmia, pyæmia, septic meningitis, septic broncho-pneumonia, suppurative nephritis, cellulitis. It appears from this that, besides the injuries already mentioned, a septic process causes the death rise in almost all cases. The predominance of this process in causing death in surgical cases probably accounts for the difference in the numbers of the death variations in medical and surgical cases.

Medical Cases.

Fall of 5°.—Phthisis.

4°.—Typhoid fever, hæmorrhage (two cases); intestinal obstruction, broncho-pneumonia, cardiac failure, phthisis (two cases).

3°.—Diphtheria, mitral disease, cirrhosis of the liver, hæmorrhage, cardiac failure, bronchitis, myelitis, pneumonia, chronic renal disease (two cases), tubercular meningitis (two cases), phthisis (two cases).

This list shows that large falls of temperature occur in diseases of long duration, such as phthisis, the absence of diseases of the nervous system and the comparative frequency with which cardiac affections is found are also striking facts.

* Sawyer, "The Temperature of Coma," 'Brit. Med. Journ.,' Dec. 26, 1903.

Surgical Cases.

Fall of 6°.—Intestinal obstruction, cyst of ovary, erysipelas.

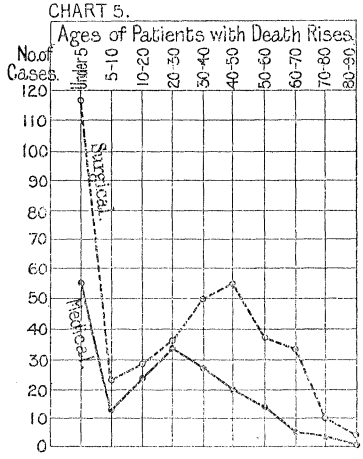
5°.—Sarcoma of pelvis, carcinoma of rectum and obstruction, compound depressed fracture of vault, scald, septicæmia, pyæmia, abscess.

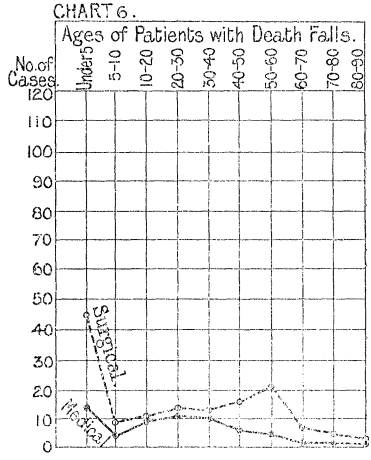
4°.—General peritonitis (two cases), pyæmia (two cases), tubercular laryngitis and phthisis, epithelioma of tongue, sarcoma of tibia.

3°.—Injury to chest and bronchitis, fractured ribs, sarcoma of face and scalp, suppurative nephritis, erysipelas, pyæmia, sarcoma of neck, cellulitis, imperforate anus, burn, cut throat, ruptured gut.

The general absence of injury and the great preponderance of sepsis are striking features in the above list. Some of the falls of temperature are dependent upon the shock following a surgical operation.

The distribution as regards the age of the patients with variations of temperature is shown in the following two charts.





The deductions, which may be made from Charts 5 and 6, are:—

1. That the variations in the temperature as death approaches are more frequent in children under the age of 5 years than at any other period of life.

2. That between the ages of 5 and 10 years there is a marked decrease in the frequency of the variations of temperature.

3. That between the ages of 20 and 50, that is, during the most active period of life, variations of temperature more commonly occur than at any other period, except in children under 5 years of age.

4. That rises and falls of temperature are relatively of the same frequency to each other at all periods of life.

Part II.

As in so many physiological controversies the various theories fall under two headings, firstly the inanimate, in which the question is examined from the point of view of chemistry, physics, etc., and secondly the animate, which deals with the phenomena of living tissues, so also in the subject of pyrexia there is found a similar condition of affairs. The inanimate theories deal with the ratio of the production and the loss of heat to each other, the disturbances of which must lead to change of temperature. The first question to be discussed is how the approach of death affects the interchange.

(*a*) It seems hardly rational to expect that the capacity for the production of heat will increase as the body approaches death. The physiological processes of the body become less and less active until they cease. In diseases such as tetanus, in which tremendous convulsions take place, there must be an enormous production of heat, and yet in this condition there is usually no pyrexia. Towards death the frequency of the convulsive seizures may somewhat subside, and after this change there is often an elevation of temperature. Under such conditions the increase in temperature may be brought about by an excess of heat production over heat loss. The majority of the other cases of death rises of temperature cannot be accounted for in this manner. Again, curari causes muscular paralysis by suspending the activity of the neuro-muscular system and, as a result, a fall in the temperature of the body occurs; but during the convulsions which are first caused by the drug the temperature rises.*

With regard to the falls of temperature at the approach of death, an explanation which is very tempting to urge, is that with the loss of the activity of the bodily processes a diminution also occurs in heat production. In support of this view may be put forward the fact that the greater the duration of the illness the more frequent is there a sudden depression of temperature. For, in diseases which are of long duration, the capacity of the organism for heat production is much more likely to become diminished than in illnesses lasting only a short time.

(*b*) The heat loss as death approaches must be diminished in almost all cases by the slowness of the circulation, shallowness of respiration, suppression of urine, etc. These changes would tend to cause a rise of temperature. Such an event would naturally be expected to be more frequent when the illness is short and the organs of heat production

* Pembrey, 'Text-Book of Phsiology,' 1898, edit. by Schäfer, vol. 1, p. 841; Bernard, 'Leçons sur la Chaleur Animale,' 1876, p. 157.

are not worn out by work under a prolonged strain. And, as has been pointed out above, if the disease should be of long duration, a fall of temperature rather than a rise would be expected to occur. The reason for this supposition is that as death approaches in long illnesses, there must presumedly be a considerable diminution of heat production, which is not counter-balanced by the small reduction of the heat lost at the surface. The investigations in the first part of this paper support these ideas, since they seem to show that rises in the bodily temperature occur more frequently in short diseases, and falls of temperature in those of longer duration.

The animate factor in pyrexia is chiefly that of the action of the central nervous system. "The nervous system exercises a control upon the loss of heat by means of the vaso-motor system, which regulates the amount of blood in the deep and the superficial parts of the body, and by the respiratory centre which controls the frequency and depth of respiration; upon the production of heat through the nerves which control the activity of the tissues, chiefly the muscles."* The heat production in a tissue is probably not under the control of that tissue itself, but its thermogenetic function is governed by its proper segment of the spinal cord. The nervous centres cannot of themselves produce heat; they can only govern the manufactories.

As the brain centres exercise a tonic control over the spinal centres which are in connection with the reflexes, sphincters, etc., so, in a similar manner, the higher centre or centres of the brain may hold in check the lower centres in the spinal cord, which give the tissues their power of heat production. The brain centres are the last to be evolved in the history of animal life, and it may be urged that they are the most complex, and therefore the most easily thrown out of gear. For this reason a generally acting death agent, such as a toxic condition, will affect and inhibit the action of the higher centres before or to a greater degree than it will damage the lower. Whenever the higher centre is cut off from the lower, the latter becomes exaggerated in its action. This is well seen in the spastic condition when the reflexes etc., are exaggerated. In a similar way, with the commencement of dissolution of the higher centres, a death elevation of temperature may be expected to result.

The fallacy in reasoning from the above analogy is that, in the one case, the facts deal with a reflex centre, and in the other, as far as is understood, with an automatic. How far these differ in regard to their relation to the higher centres, it is impossible to say, but one can instance the acceleration of the automatic and rhythmic centre of the heart when the inhibitory control of the vagus is cut off.

An important fact which this investigation shows is that, as death approaches, there is a tendency for a sudden rise in the bodily

* Pembrey, Schäfer's 'Text-Book of Physiology,' 1898, vol. 1, p. 854.

temperature. In about 2,500 medical and surgical cases, an elevation of temperature of over 1°·5 was found in 26 per cent., or just over a quarter of all the cases, while a fall occurred in 8 per cent. only. The percentage of rises of temperature in surgical cases is 37, and in medical 15. It is a most remarkable fact that this sudden elevation of temperature is observed to take place so frequently in surgical cases (in over a third of all the cases examined), and that this change should be found to occur more than twice as often in surgical as in medical cases. As the surgical diseases in these records are of shorter duration, as a rule, than the medical, the tissues in consequence have not been so long exposed to abnormal conditions, and so their heat producing functions are less likely to be impaired. Again, falls of temperature are proportionally much more common in patients dying from disease than from injury. It may be presumed, therefore, that the loss of control of the nerve centres in an exhausted organism only occasionally results in an elevation of the bodily temperature, whereas with less exhausted tissues an increase in the animal heat occurs. From these considerations it would appear that heat production is constantly in excess, and that in consequence of this the organism must exercise some tonic control over the process, in order to keep its temperature at a constant level.

The idea of the thermogenetic control of the higher centre over the lower gives point to the modified and accepted view of Liebermeister that, "in consequence of the injurious action of the fever-producing cause, the organism loses its power of keeping itself at the normal temperature."* The poison will, unless it has special affinities, affect the higher and the more complex centres before the lower. Hence, the "spastic" over-production of heat which may result in fever. The great frequency of death rises of temperature in cases of head injuries, some spinal injuries, meningitis, brain diseases, etc., emphasises the possible cutting off of the controlling function of the higher centres. On the other hand, it should be remembered that many of the patients had pyrexial temperature charts, it may be for some days before the preagonistic variations of temperature occurred. The regulation of the bodily heat in these cases was already partially out of the control of the nervous system, and the further elevation of temperature during the last 12 hours of life may be thought to be due to an increasing loss of this control on the part of the organism.

In small animals, after section of the spinal cord in the cervical region, the temperature falls rapidly; in larger animals, such as dogs, if kept in an envelope of non-conducting material in an ordinary room, the temperature of the body rises to above that of fever, but without clothing the temperature rapidly falls until the animal dies

* Burdon Sanderson, Allbutt's 'System of Medicine,' vol. 1.

in collapse.* In man, according to Sir Benjamin Brodie, section of the spinal cord in the cervical region causes pyrexia, but very discordant results have been obtained by other observers on cases with similar injury to the nervous system. Dr. Pembrey's explanation of these contradicting results seems to be the correct one. He says: "The section of the spinal cord high up in the cervical region abolishes the power of regulating temperature. When the patient is exposed even to moderate cold, his temperature falls owing to the increased loss of heat and to the diminished production of heat. On the other hand, if the weather be hot and the patient be too well covered with bed clothes, his temperature rises and may reach a dangerous height, owing to the diminished loss and the increased production of heat in the body. In the paralysed man the production of heat rises and falls *with* the external temperature."† And Sir John Burdon Sanderson writes: "Section only shows the abnormal facility with which the body yields to the influence of outside conditions."‡

It might be urged that the variations of temperature, just before death, are due to a similar condition, but obviously this cannot be the case, for after section of the spinal cord many other factors arise which are not present in those patients who suffer from no such lesion of the nervous system. After section, the respiratory movements are altered in character, and respiration is entirely performed by the action of the diaphragm, and in consequence there is less loss of heat through this channel. Again, the muscles are paralysed, and, therefore, cannot produce the normal amount of heat, while the sweat glands are no longer active, and thus less heat is lost by the evaporation of moisture from the external surface. For these reasons alone the death variations of temperature found in the patients who are considered in the first part of this paper are in no way analogous to the changes which occur after section of the spinal cord in the cervical region.

Arguing from the supposition that the higher centres have a tonic control over the lower, it is to be expected that stimulation of the higher centres should lead to a still further control and diminution of the action of the lower. In this way falls of temperature may be caused. How far a toxic agent will stimulate it is difficult to say. It is possible that some antipyretic drugs may act in this way, such as quinine and salicylic acid. Other substances seem too powerful to stimulate and would appear to paralyse the higher centres. Smaller doses of the poison, however, may act as a stimulant, first to the higher and then to the lower centres, the former being affected before

* Burdon Sanderson, "On the Process of Fever," 'The Practitioner,' vol. 16, 1876, p. 426.

† Pembrey, Schäfer's 'Text-Book of Physiology,' 1898, vol. 1, p. 862.

‡ Burdon Sanderson, "On the Process of Fever," 'The Practitioner,' vol. 16, 1876, p. 428.

the latter. It may be that for this reason, there is a slow rise of temperature in some diseases; while in others of more severe onset, there is a sudden elevation of temperature, which may be due to paresis of the higher centres. Septic conditions show frequently changes of death temperature, which may be the result of :—

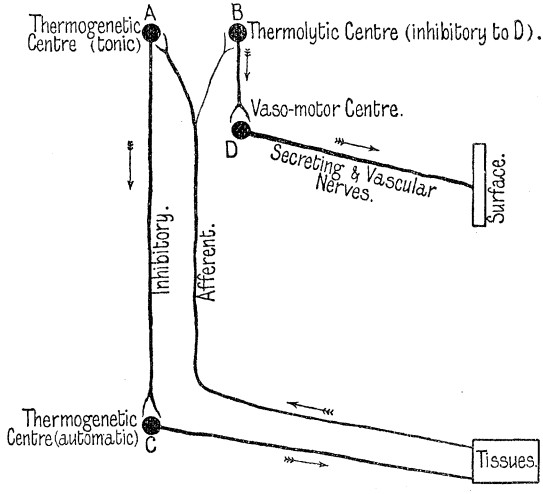
1. Stimulation of the higher centres over the lower, producing fall of temperatures.
2. Paralysis of the higher centres over the lower, producing rise of temperatures.
3. Simultaneous paralysis of higher and lower centres producing no change.
4. Special poisons may affect higher and lower centres differently.

There seems to be some evidence, therefore, in favour of the view that a higher centre in the brain controls the thermogenetic centres in the spinal cord, but it does not follow, when there is an increased heat production through the removal of this control, that there must necessarily be pyrexia. An increase in the loss of heat may keep the temperature at the normal level. In patients, however, who are dying, there is a tendency for the amount of heat lost to be diminished, the evidence for which has been pointed out above. Besides this natural tendency, means are constantly employed to prevent falls of temperature in the failing, by increasing the amount of bed-clothes, by using hot bottles, by bandaging the limbs before operation, etc. This slight diminution in the amount of heat lost may be able to prevent the temperature of the body falling, but it would hardly be sufficient to raise it many degrees without some increase in heat production. From these considerations it would appear that the variations in bodily temperature as death approaches must be dependent in many instances upon the increased amount of heat production and not upon the diminution of heat lost. As these variations are so constant, there is an indication that, although the centre which controls thermolysis, heat-loss, may be the chief factor in keeping the body at a normal temperature, yet the centre which controls thermogenesis plays a more important part than has lately been attributed to it.

The thermolytic centre probably has an inhibitory effect upon the vasomotor centre, *i.e.*, over vaso-constriction, in a similar manner, we think, to the action of the upper thermogenetic centre upon the lower in the spinal cord. As the lower thermogenetic centres tend to exaggerate the amount of heat produced in the tissues, so the vasomotor centre by constricting the vessels tends to diminish the amount of heat being lost; the latter effect being counterbalanced by the inhibitory action of the thermolytic centre. The action both of the lower thermogenetic centre and also of the vasomotor centre, when not controlled by the higher centres, seems to be that of raising the bodily temperature.

Whatever effect the fever-producing agent has upon the controlling power of the higher thermogenetic centre, it will probably act in a similar manner upon the thermolytic centre. If this should be the case, paralysis or weakening of the functions of these two centres would result in a much higher elevation of temperature than if the thermogenetic controlling centre in the brain alone were affected.

The following diagram shows the hypothetical relationship of the different nerve centres which take part in the regulation of the bodily temperature. The afferent path from the surface to the vaso-motor centre has been left out for the sake of clearness.



If A or B be paralysed or weakened, there is a tendency to pyrexia; if A and B be paralysed or weakened, there is a tendency to hyperpyrexia; if C or D be paralysed or weakened, there is a tendency to a fall of temperature.

If A or B be stimulated, there is a tendency to a fall of temperature; if A and B be stimulated, there is likely to be an extreme fall of temperature; if C or D be stimulated, there is a tendency to pyrexia.

From these considerations, and from the facts which have been elicited by a careful study of the death variations of temperature, the following theory for the causation of pyrexia seems to present itself. Pyrexia is due to two factors, to an augmented production of heat owing to the activity of the thermogenetic centres in the spinal cord being no longer perfectly controlled by the higher centre in the brain, and to a diminished loss of heat owing to the weakening of the functions of the thermolytic centre; the power of the two higher centres being weakened or paralysed by the morbid products or

toxines of the affection from which the organism is suffering. In other words, normal temperature is preserved by a mutual see-saw action of these centres—the thermogenetic and the thermolytic.

We recognise fully that, for a more perfect understanding of death temperatures, it is necessary for the observers to examine the patients for themselves, and not to trust to records, however many or accurate they may be, so that they can note in each case the changes in the skin, the circulation, the respirations, etc., concurring with the variations of the bodily temperature. Nevertheless, we venture to put forward our investigation and views, not as physiologists, but as clinical observers, with the hope of pointing out new lines of research, by which may be increased the knowledge of the regulation of animal heat.

"A Note on the Action of Radium on Micro-organisms." By ALAN B. GREEN, M.A., M.D. (Cantab.). Communicated by Sir MICHAEL FOSTER, K.C.B., F.R.S. Received April 11,—Read May 5, 1904.

[PLATE 11.]

The radium salt used in these experiments was 1 centigramme of radium bromide, bought of Messrs. Buchler and Co., of Brunswick, in June, 1903. It was contained in a vulcanite and brass capsule, fronted with thin talc. The radium was enclosed immediately behind the talc, and the circular area over which it was spread was about 3 mm. in diameter. The radium emanations which were applied to micro-organisms were such as passed through the talc, *i.e.*, the β and γ rays.

Dr. E. F. Bashford, to whose kindness I am greatly indebted for the use of the radium, has informed me that Sir William Ramsay tested the preparation for the intensity of its combined β and γ rays, the latter being a practically negligible quantity. The results showed that, on comparison with samples of radium bromide giving a virtually pure spectrum of radium, these rays were practically 100 per cent. This radium salt was, in fact, a pure preparation of radium bromide.

Dr. Bashford also informs me that this radium bromide caused pigment to disappear after 18 days from a mole with 15 minutes' exposure, the talc being in contact with the surface of the mole. Five minutes such exposure produced a marked skin reaction, while 20 minutes' exposure caused a reaction proceeding almost to ulceration.

I found that the radium was itself luminous, and that it could